Endovascular aortic repair of a postdissecting thoracoabdominal aneurysm using intraoperative fusion imaging.

Adrien Kaladji, Aurélien Dumenil, Miguel Castro, Pascal Haigron, Jean-François Heautot, Stéphan Haulon

Endovascular Aortic Repair Of A Post-Dissecting Thoracoabdominal Aneurysm Using Intraoperative Fusion Imaging.

Kaladji A[1,2,3] , Dumenil A[2,3], Castro M[2,3], Haigron P[2,3], Heautot JF[4], Haulon S[5]

(1) CHU Rennes, Department of cardiothoracic and vascular surgery, F-35033 Rennes, France
(2) INSERM, U1099, F-35000 Rennes, France
(3) University Rennes 1, Signal and Image Processing Laboratory (LTSI), F-35000 Rennes, France
(4) CHU Rennes, Department of medical imaging, F-35033 Rennes, France
(5) CHRU de Lille, Vascular surgery, INSERM U1008, Université Lille Nord de France, France

Corresponding author:

Adrien Kaladji, Service de Chirurgie Vasculaire, CHU Hôpital Pontchaillou, 2 rue Henri Le Guilloux, 35033 Rennes cedex 9, France

Email: kaladrien@hotmail.fr

Abstract

Computer-aided imaging can aid complex endovascular repair of aortic dissections in locating the narrow true lumen and identifying perfusion of visceral vessels by the true and/or false lumen. While these anatomical data are available for analysis during planning, they are not readily available during the procedure with conventional imaging systems.

We report the use of "Fusion Imaging" to facilitate the treatment of a post-dissection thoracoabdominal aneurysm. The preoperative computer tomography angiography was processed and the true and the false lumens individually colour-labeled. These data were then superimposed on the fluoroscopy images in order to facilitate deployment of a fenestrated endograft.

Introduction

The endovascular aortic repair of complex aortic aneurysms with fenestrated or branched grafts requires accurate planning and therefore, high quality imaging. Computer tomography angiography (CTA) volume data are interrogated and manipulated with an appropriate workstation to provide multiplanar reconstructions and thereby accurately size and plan bespoke endografts. Most operative imaging systems provide only two-dimensional fluoroscopy images with various refinements such as subtraction and roadmapping to facilitate positioning of the endograft. Conventionally, none of the pre operative CTA data (position of the aortic branches, true and false lumen location, thrombus or calcifications) are directly available to the operating surgeon. Current developments in image guided therapy and computer aided surgery in vascular surgery[1] are being combined to provide the pre-operative data to the surgeon during the operation. This case report describes the use of fusion imaging (3D preoperative CTA overlaid onto the 2D live fluoroscopy image) during the endovascular repair of a post-dissection thoracoabdominal aneurysm using a four vessel fenestrated endograft.

Report

A 46 year-old woman with a systemic lupus erythematous presented with aneurysmal dilation of a chronic thoraco-abdominal aortic dissection. Previous aortic procedures included ascending aortic replacement, aorto bi-iliac inlay grafting and replacement of a segment of descending aorta with patch reimplantation of the origin of the distal intercostal arteries. The presenting thoracoabdominal aortic aneurysm (TAAA) included the visceral artery origins, which had not been previously treated. Given the multiple previous aortic operations, endovascular surgery was the preferred treatment option. The preoperative CTA was analyzed using an Aquarius workstation (Tera Recon Inc., SanMateo, CA, USA.). It showed a 60 mm diameter dilated dissection with a Crawford type III anatomical distribution (Fig. 1A and 2A). There was evidence of a communication between the true and false lumen at the level of the LRA origin (Fig. 1B). The true lumen was narrow (7×16 mm) at the level of the visceral bearing aortic segment. Endovascular exclusion using two tubular components was planned : a proximal thoracic component to be positioned in the previously surgically placed descending thoracic aorta graft with its distal margin 20 mm proximal to the CT origin; a distal fenestrated component to be positioned with 3 stent overlap in the proximal thoracic component, and in the main body of the previously surgically placed infra-renal bifurcated bypass distally. The distal component included two large fenestrations for the CT and SMA and two small fenestrations for the renal arteries. The small fenestrations were planned with preloaded guidewires[2]. The procedure was performed in the TheraImage plateform angiosuite at CHU de Rennes. A first image processing (Fig. 2A) was performed before the intervention using the Endosize[3] workstation (Therenva, Rennes, France) in order to label on the CTA the true and false lumen with different colors (Fig. 2B). This post processed aortic volume data was then imported into the Syngo software. To construct the fusion image, this software needs to match the preoperative CTA with an intraoperative CT perfomed with a c-arm digital flat-panel detector cone beam CT (CBCT) (Artis zeego, Siemens Healthcare, Forchheim, Germany). This acquisition is performed with a dedicated program allowing an automatic 200° rotation without injection limited to the abdomen. A total of 350 images are created and then reconstructed with the Syngo software, producing CT-like images. The bony structures between the CT like images and the preoperative CTA are manually aligned. When the alignment is accurate, the vascular structure can be superimposed onto the 2D live fluoroscopic images. The color labeled process allowed an accurate real-time 3D visualization of the true and false lumens during the procedure (Fig. 2C). Fusion imaging also proved very helpful in the catheterization of target vessels (Fig. 2D), so much so that contrast injection was not required before target vessel catheterisation, only being necessary to check patency after placement of the covered stents. An early type III endoleak was identified arising between the two aortic components. This was resolved by the adjunct of an aortic extension cuff. There was no type I or III endoleak on final completion angiography . The duration of the operation was 245 minutes, contrast volume 145 mL and fluoroscopy time 60 minutes. The early postoperative follow-up was uneventful, no spinal cord ischemia symptoms were depicted. The 1 month postoperative CTA (Fig. 3) revealed a type II endoleak and four patent target vessels.

Discussion

Total endovascular repair of chronic dissecting aneurysms including the visceral arteries with fenestrated endografts is a challenging procedure. In the few cases that have been reported[4], authors have highlighted challenges surrounding the navigation of the true and false lumens and in catheterizing visceral vessels. Aneurysm exclusion demands that the proximal and distal sealing zones of the endograft are located in the true lumen. This is often very narrow, and this may hinder both the ability to manipulate the main device and catheterize the target vessels. We anticipated technical difficulty with catheterization of the target vessels, particularly the left renal artery because of the communication between the true and the false lumen at that site. With this in mind, we designed an endograft with wires preloaded into the renal fenestrations[2]. Sheathes for the renal arteries were advanced directly through the renal fenestrations without the usual need to catheterize these small fenestrations. Catheterization of the renal arteries was then performed with a catheter advanced through the sheath parallel to the preloaded wires. This system provides stability and support for the catheter and wire being used to access the renal artery. We contend that the operative and fluoroscopy times are shortened with this system.

Neuroradiologists were the first these advanced 3D road-map software during challenging brain aneurysm repairs[5]. Geenberg et al[6] described the first use of fusion images in endovascular aneurysm repairs. With CTA fusion, 3D roadmapping is available without the need for operative contrast injection and, contrast-free thoracic endovascular repair has now been reported with this imaging technique[7]. Even if contrast is required, the location of target vessel origins and their catheterisation are easier and fluoroscopy times are reduced.

It is important to acknowledge that the deformations imposed by stiff guidewires and sheaths can lead to a mismatch between the overlayed 3D preoperative CT and the real location of the arterial structures (Fig 2D). Further technologies might anticipate such deformations and propose a deformed aortoiliac overlay.

This experience describes one application of fusion imaging but the ultimate aim of computer aided imaging and surgery is to simplify complex surgery by making all pre-operative data available and usable in the operating room.

Conclusion

In this article, we report the case of an endovascular repair of a complex thoracic dissection facilitated by "fusion imaging". While fusion imaging is a new technology in the vascular field, we anticipate that with further developments it will be a useful tool for endovascular procedures to reduce contrast and radiation dose.

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Conflict of interest

SH is a consultant for Cook medical

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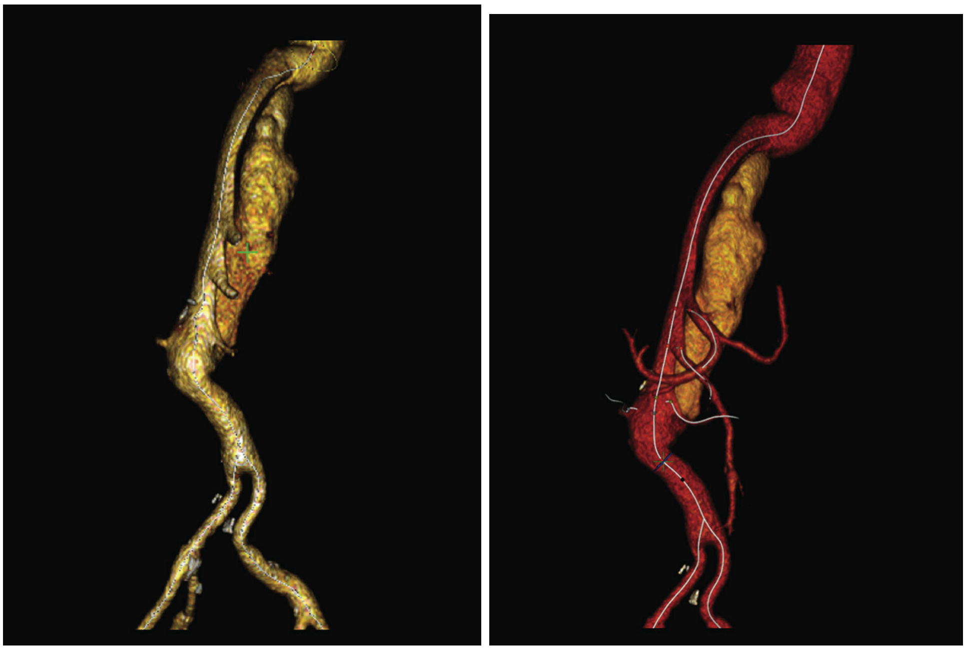
Figures

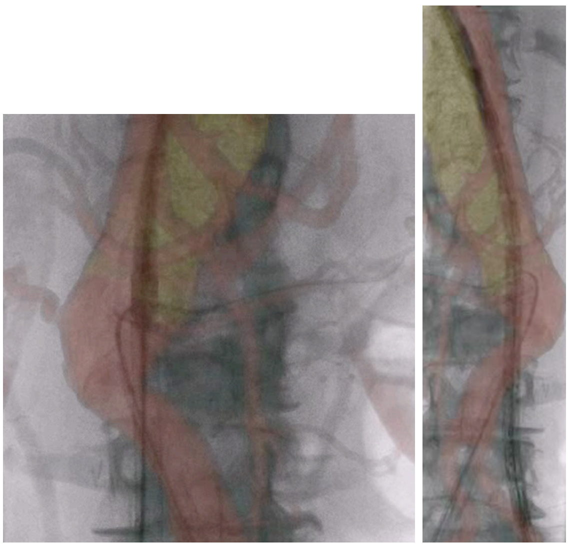
Figure 1 Pre operative sagittal (figure 1A) and axial (figure 1B) CT Multiplanar reconstructions. The white arrow shows the proximal entry tear located at the thoracoabdominal junction and the black arrow the exit tear near the origin of the left renal artery.

A B

Figure 2 Preoperative 3D Volume rendering of the aorta before (figure 2A) and after (figure 2B) postprocessing of the true lumen in red and the false lumen in yellow. The postprocessing volume is then superimposed onto the 2D intraoperative fluoroscopy image (Figure 2C): the left renal artery was canulated with a guidewire to check the accurate location of the target vessels with the fusion. The position of the endograft delivery system within the true lumen (red area) was confirmed (Figure 2D).



A B



C D

Figure 3 Postoperative CT control confirmed patency of all target vessels, and no residual flow in the false lumen.